Cold Preservation Technology

Quality chances of Frozen Foods

Physical changes and quality
Freezer burn

- Freezer burn is a condition that occurs when frozen food has been damaged by dehydration and oxidation due to air reaching the food.
- Freezer burn is caused by improper freezing practices and/or exposure to air, e.g:
- caused by food not being securely wrapped in air-tight packaging.
- caused by changes in temperature and differences in RH.
- All foods are susceptible to this effect, but foods with higher moisture content (meats, fruits, ice cream, etc.) will develop it more quickly.

Shrimp that underwent freezer burn

Freezer burn

- Freezer burn appears as grayish-brown leathery spots on frozen food,
- occurs when air reaches the food's surface and dries the product.
- Color changes result from chemical changes in the food's pigment.
- Freezer burn does not make the food unsafe; it merely causes dry spots in foods.

To prevent freezer burn:

- Packaging of food
- Prevent fluctuations during frozen storage.

It is usually in the form of patches of light-colored tissues, produced by evaporation of water, which leave air pockets between meat fibers.

Physical changes and quality
Protein denaturation

Freezing cause denaturation of proteins in particularly muscle foods.

Denaturation of proteins leads to

- an increase in loss of water holding capacity,
- a decrease in protein extractability,
- a decrease in protein solubility,
- a decrease in sulfhydryl groups, and
- a slight loss in ATPase activity

Cryoprotection

- A cryoprotectant is a substance used to protect biological tissue from freezing damage (i.e. that due to ice formation).
- Arctic and Antarctic insects, fish and amphibians create cryoprotectants (antifreeze compounds and antifreeze proteins) in their bodies to minimize freezing damage during cold winter periods.
- Cryoprotectants are generally added to protect fish myofibrillar proteins from freeze denaturation during frozen storage.

Some cryoprotectants

- Polydextrose,
- sucrose, and
- Sorbitol

Sucrose is usually combined with sorbitol to reduce sweetness. The cryoprotective effect of sugar is enhanced by adding polyphosphate.

Chemical Changes and Quality
Rancidity

- Rancidity is the oxidation of fats present in food products and is characterized by unpleasant odours and flavours due to the change in the chemical composition of fats.

causes

- loss of color, and
- development of off-flavors.
- Freezing results in a concentration of solutes, which catalyze the initiation of oxidative reactions and disrupts and dehydrate cell membranes, exposing membrane phospholipids to oxidation.
- Oxygen availability and tissue composition play important roles in the acceleration of lipid oxidation.

Chemical Changes and Quality
Color, Flavor, and Vitamin Loss

Color loss:

- The most important color changes in fruits and vegetables are related to three biochemical or physicochemical mechanisms :

(a) changes in the natural pigments of vegetable tissues (chlorophylls, anthocyanins, carotenoids),

(b) development of enzymatic browning, and

(c) breakdown of cellular chloroplasts and chromoplasts.

Color loss in poultry products

- a light surface color for carcasses is considered important and is best achieved with rapid surface freezing, which generates a smooth chalky white surface.
- This is achieved by supercooling the product and forcing nucleation of a high number of small ice crystals.
- These crystals stay small because there is little water migration to already formed crystals during such a fast process.
- Numerous small ice crystals cause the surface to reflect light and appear white in color.
- Darkening of bones is a condition that occurs in immature chickens and has become more prevalent as broilers are marketed at younger ages.
- Darkening may arise during chilled storage or during the freezing
- and defrosting process.
- It occurs because some of the heme pigment normally contained in the interior of the bones of particularly young chickens leaches out through spongy areas and discolors the adjacent muscle tissues.

Color loss in crustacean seafood

- A dark discoloration defined as blackspot or melanosis is developed after the trauma of the capture, string, and thawing process;
- It is unattractive to consumers and reduces the market
- value.
- Sodium metabisulfide is an effective to prevent blackspot.
- Quick freezing appeared as a good method in addition to the sulfiting agent to prevent the melanosis phenomenon.

Flavor and aroma loss

- Freezing affects the flavor and aroma of frozen foods.
- For example, freezing of strawberries is usually associated with a reduction in aroma and the development of off-flavor.
- The decrease in aroma is due to a rapid decomposition and diffusion of esters.
- The off-flavor of frozen strawberries differs from that of frozen vegetables.
- Off-flavor in frozen vegetables is usually due to insufficient blanching.
- In fish and seafood, FA is formed during cold storage by enzymatic decomposition of TMAO.
- It is a good objective criterion of time-temperature exposure in frozen gadoid species.
- The FA reacts with proteins, thereby decreasing their solubility in salt and buffer solutions.

Vitamin loss

- Retention of nutritional components in foods is a concern when any type of preservation method is used, but freezing is probably the least destructive.
- The destruction of vitamin C (ascorbic acid) occurs during
- freezing and frozen storage.
- This loss is influenced by blanching conditions, types of freezing, package types, and time-temperature conditions.
- The loss is mainly due to the oxidation or to the action of ascorbic
- acid oxidase.
- There is a 10-fold increase in the rate of loss of ascorbic acid per 8.9°C rise in storage temperature of frozen vegetables.
- Generally, frozen vegetables stored at -24°C displayed better ascorbic acid retention than those at -12°C and -18°C, respectively.
- Blanching improves ascorbic acid retention in vegetables.

Vitamin loss

- Vitamin B losses sometimes occur in frozen meat products.

- Vitamin B losses may be significant in frozen poultry products,but most losses are the result of the subsequent thawing and cooking treatments rather than of the freezing process.

- Freezing, when properly done, can preserve more nutrients than other methods of food preservation.

Chemical Changes and Quality
Release of Enzymes

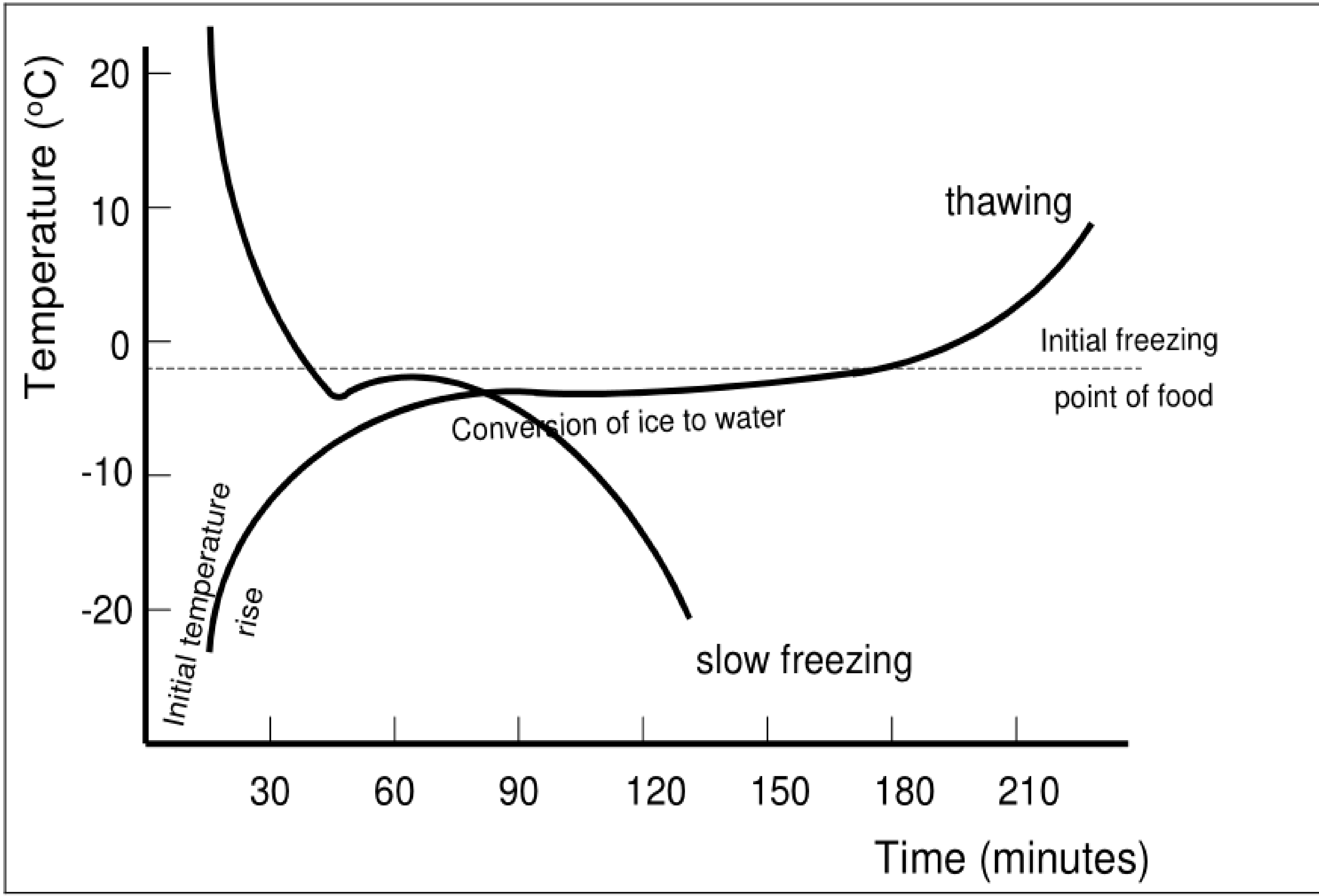
- The disruption of plant or animal tissues by freezing leads to the release of enzymes bound to the structures.
- Beef and pig skeletal muscle contain two isozymes of glutamic-oxalacetic transaminase: one in the mitochondria and other in the sarcoplasm.
- Freezing and thawing cause a remarkable increase of glutamic-oxalacetic transaminase activity in the muscle press juice.
- Fish contains malic enzymes in two forms: free and latent. The latter is solubilized by the disruption of the tissue caused by freezing and thawing.
- The activity of cytochrome oxidase in extracts of tissues after freezing and thawing is increased by 15 times in chicken's liver, 2.5 times in trout, and 4 times in beef muscle compared to extracts of unfrozen samples.

Shelf-life of frozen foods at -18oC

Food	Number of Weeks/Months
Fruits	12 to 18 months
Vegetables	12 months
Beef	6 to 12 months
Ground Beef/Veal/Lamb	3 months
Ham (not sliced)	2 months
Lamb	6 to 9 months
Pork Roast	3 to 6 months
Ground Pork	2 months
Pork Chops	3 months
Stewing Meat	4 months
Veal Roast	6 to 9 months
Veal Chops	4 months
Chicken/Turkey	12 months
Ducks/Geese	3 to 6 months
Poultry Cut-up	6 months
Butter	9 months
Cheese	6 months
Ice Cream	3 weeks
Milk	3 weeks
Fish/Salmon/Lake Trout	2 months
Fish/Haddock/Cod	3 to 4 months
Bread (yeast)	6 months
Bread (quick)	2 to 3 months
Cakes/Frosted	2 to 3 months
Cake/Unfrosted	2 to 4 months
Cookies/Baked	9 to 12 months
Cookies/Unbaked	4 to 6 months
Pies	3 to 4 months

Thawing

- Reverse process of freezing.
- Thawing as a final and obligatory step of the freezing process is quite important.
- Involves transferring heat to a frozen product.
- Thawing time is longer than freezing time.
- The thermal conductivity coefficient of water at $0^{o}C$ is 0.561 W/m K, whereas ice at the same temperature is 2.24 W/m K.
- The thermal diffusivity of water at $0^{o}C$ is 1.3x10-7 m^2/s, whereas ice at the same temperature is 11.7x10-7 m^2/s.
- According to these values, it is seen that the temperature of ice changes 9 times faster than water.
- These values reveal why the physical change of freezing and thawing is different.



Temperature changes during thawing

Thawing methods

Conventional methods

1.Refrigerator thawing (thaw food in a cooler, keeping its temperature at 5^{o}C or lower)

2. Cold water thawing

3. Microwave thawing

4. Thawing at room temperature

Novel methods

1. High-pressure thawing

2. Ohmic thawing

3. Acoustic thawing

**Frozen vegetables thaw best by direct cooking.